Curriculum Ideas for SpaceSim from our lead programmer, Dr. Laura Monroe

The following curriculum concepts have been developed by Dr. Laura Monroe to aid with curriculum design and development for SpaceSim and to provide discussion ideas for AEL sites and classrooms utilizing the SpaceSim software.

1. The first cognitive challenge a student will need to meet will be spatial orientation. During the AEL demo, I noticed that people found the spatial orientation to be quite difficult at first. Although the finished simulation will include some form of control panel providing orientation information, the challenge of coming up with a mental model of orientation and position in space must still be addressed. The curriculum component associated with this could be mathematically oriented. Spatial visualization is a mathematical skill related to success in geometry and later success in calculus.

The easy mode incorporated into the software allows changes in position and orientation, but does not incorporate acceleration. This means that once the student lets go of the joystick, she stops moving. This would be a good place to discuss spatial orientation, since the student won't be distracted by acceleration or orbital motion. The students could work in pairs -- one student could give the other a goal ("rotate the shuttle so that you're facing the docking module") and the other could move the shuttle in that direction. Alternatively, one student could give a joystick motion and the other could predict what orientation the shuttle would have after the motion.

2. In medium mode, the student will have to adjust to the fact of brakeless acceleration. When the joystick is applied, the speed continues to increase until the joystick is released. After the joystick is released, the shuttle continues to move in the same direction and at the same speed. To stop, it is necessary to accelerate in the opposite direction. This illustrates Newton's first law of motion.

Stopping will be a skill for the students to learn, as will accelerating gently (by holding the joystick down in one direction, the student could eventually go as fast as he'd like -- but will need a correspondingly long time to stop, by which time he might already have collided with the ISS).

There is also an issue with acceleration in rotation, related to the issue of spatial orientation above. Rotation around the x, y, or z axes is easy enough to stop, but it is harder to stop rotation around some arbitrary axis in 3-space. This is because it is easy to make a mental map between a rotation around the x, y, or z axis and the joystick pitch, roll or heading which will stop that (simple) rotation, but it is much harder to map an arbitrary rotation to some twisting of the joystick which will slow and eventually stop that rotation. Students should be encouraged to discover that it's best to rotate gently around one axis at a time and stop that rotation completely before initiating another.

There is a freeze mode implemented in both the medium (acceleration) and hard (acceleration + gravity) mode. When the right bottom flybox button is pushed, all motion stops for as long as the button is held down. This is intended to give the students time to assess their position and think through their next actions.

3. Gravity and orbital mechanics are being implemented at the hardest level. This models Newton's Law of Universal Gravitation. At the outset of the simulation, both the shuttle and the ISS are moving at a stable orbital speed for their respective altitudes.

The ISS never deviates from its stable orbit during the simulation. The shuttle's rockets are activated by the motion of the joystick, so the shuttle is acted upon by the force of its rockets, the force of gravity, and its previous momentum.

One issue here will be the counterintuitive nature of flying under the influence of gravity. For example, if the ISS were directly in front of the shuttle, the natural thing to do would be to speed up in the forward direction to catch up with it. However, this speedup in the forward direction would put the shuttle into a higher orbit and so the shuttle would then be higher than the ISS.

Students will probably be helped by discussion of orbital mechanics both before and after their gravity-enhanced flight. Discussion before will give them a mental model to help them fly. Discussion after will help them assimilate what they've learned, and also make use of the flight itself as an example. Also, conversation during the flight will help them put things together on the spot.